QUIZ 1 Solutions (Robotics) 22 Sept 2003

1. $^{A}x_B = \begin{pmatrix} 2-5 \\ 6-6 \\ 5-2 \end{pmatrix} = \begin{pmatrix} -3 \\ 0 \\ 3 \end{pmatrix} = \begin{pmatrix} -3 \\ 0 \\ 3 \end{pmatrix} \times \dfrac{1}{\sqrt{(-3)^2+(3)^2}}$

8 Marks

after normalizing

$^{A}y_B = \begin{pmatrix} 0 \\ -1 \\ 0 \end{pmatrix}$ (along negative y axis of Frame A)

$^{A}z_B = {}^{A}x_B \times {}^{B}y_B$

$^{A}p_B = \begin{pmatrix} 5 \\ 6 \\ 2 \end{pmatrix} \rightsquigarrow {}^{A}T_B = \begin{pmatrix} ^{A}x_B & ^{A}y_B & ^{A}z_B & ^{A}p_B \\ 0 & 0 & 0 & 1 \end{pmatrix}$ //

2. $^{A}T_{C_0} = {}^{A}T_C$ = initially configuration of C in A

20 marks

$^{A}T_{C_1} = Rot(x, 30^\circ)\, {}^{A}T_{C_0}$ where $Rot(x,30^\circ) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 30^\circ & -\sin 30^\circ & 0 \\ 0 & \sin 30^\circ & \cos 30^\circ & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

$^{A}T_{C_2} = {}^{A}T_{C_1}\, Trans(1,2,3)$ where $Trans(1,2,3) = \begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

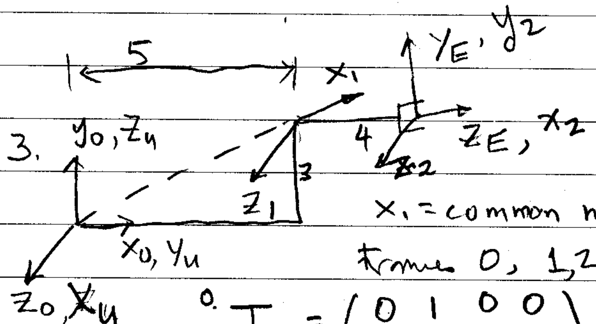
$^{B}T_{C_2} = ({}^{A}T_B)^{-1}\, {}^{A}T_{C_2}$

$^{B}T_{C_3} = Rot(y, 60^\circ)\, {}^{B}T_{C_2}$ where $Rot(y,60^\circ) = \begin{bmatrix} \cos 30^\circ & 0 & \sin 30^\circ \\ 0 & 1 & 0 \\ -\sin 30^\circ & 0 & \cos 30^\circ \\ 0 & 0 & 0 \end{bmatrix}$

$^{A}T_{C_3} = {}^{A}T_B\, {}^{B}T_{C_3}$

$^{A}T_{C_3} = {}^{A}T_B\, Rot(y,60^\circ)\, \overbrace{{}^{A}T_B^{-1}\, \underbrace{\underbrace{Rot(x,30^\circ)\, {}^{A}T_{C_0}}_{^{A}T_{C_1}}\, Trans(1,2,3)}_{^{A}T_{C_2}}}^{^{B}T_{C_2}}$ //

3.



x_1 = common normal to z_0 & z_1

frames 0, 1, 2 = DH Frames

	θ	r	d	α
1	q_1	0	$\sqrt{3^2+5^2}$	0°
2	q_2	0	4	0°

25 marks

$^{0}T_4 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$; $^{2}T_E = \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$; $^{4}T_E = \begin{pmatrix} n_x & o_x & a_x & p_x \\ n_y & o_y & a_y & p_y \\ n_z & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{pmatrix}$

ox=ax=ny=nz=0
nx = -1, px = 0

4. $^{0}f_E = -\begin{pmatrix} 0 \\ 0 \\ -10 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 10 \end{pmatrix}$

14 marks

$^{0}n_E = -{}^{0}R_E\, {}^{E}p_{cg} \times \begin{pmatrix} 0 \\ 0 \\ -10 \end{pmatrix}$ where $^{E}p_{cg} = \begin{pmatrix} 0 \\ 0 \\ 5 \end{pmatrix}$

$^{0}R_E$ = 3x3 (upper left) of $^{0}T_E$

$\tau = {}^{0}J_E^{T} \begin{pmatrix} ^{0}f_E \\ ^{0}n_E \end{pmatrix}$ τ = joint actuator forces //